SOLAR AND TERRESTRIAL CHANGES.

THE problem of the relations between sun-spots and other solar phenomena and weather has engaged the attention of men of science for many years past. The results of their investigations have not, perhaps, been so satisfactory or conclusive as were at first anticipated, but this, fortunately, has not diminished the enthusiasm of those interested in the solution of the problem. The ordinary public who were attracted by the apparent simplicity and probability of the relations suggested have undoubtedly been disappointed with the results. There has hence been a tendency for some time past to depreciate investigation in this field of science. On the other hand, the experience of the recent droughts and famines in India, Australia, and South Africa has directed attention strongly to the probable relation between variations of solar activity and the larger variations of rainfall over the earth's surface. The aqueous vapour precipitated as rain over large land areas such as India is produced by evaporation over distant oceanic areas, and is thence carried to the areas of discharge by the larger atmospheric currents. These actions are the direct results of the conversion of solar energy, and any large variation in the supply of that energy must be accompanied with, and followed by, corresponding changes in the amount of evaporation and atmospheric movement, and hence, also, of amount and distribution of rain. The determination of the relations thus indicated is not merely of value from the scientific standpoint, but has important practical bearings, as it may lead to a satisfactory method of long-period weather forecasting —a question which is largely engaging the attention of meteorologists at the present time.

Three lines of observation (and hence also of investigation) carried on at the present time furnish data for the solution of the problem. These are the observations of terrestrial magnetism, of terrestrial atmospheric meteorology, and of solar phenomena.

A large number of magnetic observatories, furnished with the most delicate and sensitive instruments, provide a continuous record of the changes of the earth's magnetic state by its action on magnetised needles at the earth's surface.

The work of meteorological observation has made great progress during the past twenty-five years. It has not only been extended and improved, but is carried on much more systematically than hitherto. Unfortunately its record is very imperfect, as it is probably not too much to say that over at least five-sixths of the earth's surface, including the greater part of the interior of Asia and Africa, and over the larger oceanic areas and the Polar regions, the amount of observation is exceedingly small and of little value for the solution of the problem. There is hence a continuous record of the meteorological changes of the earth's atmosphere over barely one-sixth of its surface. There is, moreover, no general collection and publication of the meteorological data in such a form as to give a continuous history of the larger atmospheric variations and changes in progress over even that sixth part of the earth's surface.

The third branch of observation, that of solar phenomena, has made wonderful progress during the past fifty years. Previously the telescopic examination of the sun's surface had disclosed the eleven-year periodicity of the sun-spots. Latterly the combination of the spectroscopic and telescopic observation of the sun has revealed the complexity of the changes in progress throughout the depth of its atmosphere, and of which the sun-spots are only one and a very partial expression. This field of investigation is so promising that solar observatories have been established in many countries, and a continuous record of the solar changes, so far as they are indicated by present methods of observation, is now possible by combining the data furnished by all the observatories. The work of correlating the three classes of observation has, however, not yet been commenced in a systematic manner, although the necessity is now fully recognised.

It is now generally, if not universally, admitted that the sun is practically the sole source of the energy which maintains the movements of the earth's atmosphere. It is the centre of a continuous outflow of radiant energy, a very small portion of which is intercepted and appropriated by the earth, where it is converted into other forms of energy. The investigation of the rate of this flow of energy and its time variations, the analysis of the total energy into its elements as that of a series of oscillatory movements of different periods and amplitudes or wavelengths, and the problem of its distribution in its passage through the atmosphere and at the earth's surface are each in little more than the initial stages. In some departments of the investigation, as, for example, the laws of the absorption of the solar energy during its passage through the earth's atmosphere, much work has been done, but with comparatively little result.

The appropriation of solar energy by the earth affects it mainly in two ways, first, as a whole, determining or modifying its magnetic condition, and secondly, partially, affecting the atmosphere and a thin surface layer of the solid or liquid mass. Any variation in the flow of solar energy, periodic or irregular, will theoretically give rise to corresponding changes in the earth's magnetic condition and its atmospheric movements. The determination of the relations between the three classes of variation is on the whole the most important problem in this field of inquiry into the solar energy and its variations and effects.

The first part of the problem, that is, the relation of the variations of solar energy (as manifested and measured by the observable changes in the number and extent of the sun-spots, prominences, &c.) to those of the magnetic condition of the earth shown by its action on a magnetised needle suitably suspended, is comparatively simple, as the earth appears to be similarly affected as a whole and throughout its whole mass. The variations are indicated as clearly and satisfactorily by an observatory in India or Australia as at Kew in England. There are undoubtedly local variations which may require to be eliminated in order to obtain the general variation. It has, however, been conclusively established by observations in different regions that there is a general parallelism between the amount and extent of the magnetic variation or disturbance and the number and magnitude of the sun-spots and prominences. The rule is, the larger the number of sun-spots the greater the amount of the magnetic variation and disturbance. The relation can, however, at the present stage only be considered as statistical, as it has not been established for single sun-spots. In other words, the observed outburst or sudden appearance of a single spot or prominence is not invariably accompanied by a terrestrial magnetic disturbance. Various reasons have been given for the failure of parallelism in detail. Hence all that can be inferred at the present time is that definite relations (of a statistical kind) of great importance have been obtained which more than justify the continuance of this branch of the inquiry, and make it desirable that the work of terrestrial magnetic observation and investigation, and of comparison with solar phenomena, should be maintained and if possible extended.

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Numerous attempts, only very partially successful, have been made to establish similar definite relations between solar and terrestrial atmospheric variations. The South Kensington observatory has done much valuable work in this direction. It is, however, doubtful whether the results obtained by any of the investigators in this branch are generally accepted.

The reasons for this very partial success are almost self-evident, and are due to the complexity of the problems presented by the movements of the atmosphere, more especially as modified by the presence of very varying amounts of aqueous vapour, the result of the processes of evaporation and condensation. The effects of the solar variation on the earth's atmosphere are, in fact, distributed and manifested in very varying proportion between the different elements of observation, and the direct effect of a solar variation on one element may be followed by an opposite effect due to variation of another element, so that the final result may be opposite in character to the initial effect. Thus an increase of solar radiant energy would, if there were no increase of aqueous vapour amount, cloud or air movement, undoubtedly increase pressure and temperature. If these changes, however, give rise to increased vertical and horizontal movement, it is possible that as a later result pressure probably, and temperature possibly, might both be decreased below their original or normal level, and hence that the observed change might be the opposite to that of the direct effect of the original variation. Also there is another source of difficulty in this branch of the inquiry, due to the fact that in the case of some of the elements of observation a positive variation over a considerable area of the earth's surface must necessarily be accompanied with a negative variation of corresponding amount in some other region as part and parcel of the total change. The changes in these elements, taken over the earth's surface, must either be completely compensatory, as is probably the case for pressure, or partially compensatory, as is undoubtedly the case for rainfall.

It is also necessary to bear in mind that the instrumental appliances for magnetical and meteorological observations are of very different orders of exactness. Magnetic instruments, more especially those for continuous autographic registration, are of great delicacy. Meteorological instruments are, on the other hand, much less delicate, and the most important of all from certain points of view, viz. the instruments for registering the direction and rate of air movement, are especially coarse, and their individual observations are necessarily affected with large errors.

The problem of the relations between solar and terrestrial meteorological variations is hence complicated and difficult. It evidently requires for its complete solution the collection and coordination of data for the whole of the earth's surface, and the careful employment of statistical methods regulated by thorough knowledge of the physics of the atmosphere.

The difficulties of the problem are great, and explain the comparative want of success of investigators hitherto. It is, however, certain from theoretical considerations that there are definite relations, and that their determination is of great importance, equally from the scientific and the utilitarian point of view.

The observational data for a more systematic investigation are now considered by many to be sufficient, if collected, compared, and discussed as a whole, to promise more satisfactory and valid conclusions than have hitherto been obtained, and perhaps a first approximate solution. This opinion found expression fully at the meeting of the British Association at Southport in 1903. Sir Norman Lockyer, director of the Solar Physics Observatory, South Kensington, read a report giving a summary of the results of previous investigations in "Simultaneous Solar and Terrestrial Changes" to Section A of the British Association. The members of the International Meteorological Committee present at the meeting joined in the discussion, and it was decided that the time had arrived for joint and concerted action. A commission to act as a subcommittee of the International Meteorological Committee was formed to discuss meteorological observations from the point of view of their connection with magnetism and solar physics. The commission held several meetings at Cambridge in 1904 during the British Association week. Several additional members were added to the commission, which now includes the names of the leading authorities in the three associated branches of science.

The chief work of the commission at Cambridge was to lay down principles for the selection of the data required for comparison, and to arrange for the choice of stations and observatories from which it would be desirable to obtain data prior to entering into communication with the various organisations that it would be necessary to ask for assistance in the collection of data.

It has been arranged that a meeting of the commission shall be held in connection with the meeting of the International Meteorological Committee at Innsbruck in September. A number of important matters will there be considered. Amongst these are the final selection of magnetic and meteorological observatories from which data are to be collected, the mode of publication of the data received by the commission, and probably, also, of the methods to be employed in the work of comparison and discussion of the data. Hofrath Prof. Julius Hann has suggested for consideration a method of determining the variation of temperature during a sun-spot period. This will, it is hoped, lead to an interesting discussion on the methods of investigation most suited and appropriate for the determination of the relations between solar and terrestrial phenomena.

THE PROPOSED COLLEGE OF APPLIED SCIENCE.

THE appearance of the preliminary report of the Departmental Committee on the Royal College of Science and Royal School of Mines, which was published in our issue of last week, brings us an important step nearer the realisation of an object after which men of science have long striven; the provision, that is, of a great metropolitan college—liberally endowed, handsomely housed, adequately equipped, and generously staffed—designed amply to supply that higher technical instruction for which there has been little provision hitherto, but upon which our well-being as a commercial and manufacturing nation ultimately depends.

The report shows that the committee has been engaged wisely in determining what precisely the existing facilities for instruction in applied science are, and in gathering the information necessary to decide what the new college should supply in addition to these, so as to place London, as the centre of the Empire, in a condition to compare educationally with Berlin, for example, or with many great American cities. It is unnecessary here to recapitulate the recommendations of the committee, but the special wisdom of

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